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PATENT ABSTRACTS OF JAPAN

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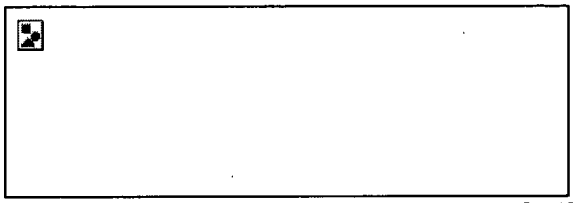

(54) **POLISHING OF METAL FILM AND POLISHING DEVICE THEREOF**

(57)Abstract:
PROBLEM TO BE SOLVED: To prevent a metal film on the surface of a wafer from being contaminated and to maintain high polishing rate of polishing of the metal film by a method, wherein when the wafer is polished, a metal film formed in the wafer is oxidized using an oxidizing agent which does not contain metallic ions, and the oxidized metal film is removed using an abrasive containing abrasive particles.
SOLUTION: A wafer 1 is formed by a method wherein a BPSG film 13, a PE-TEOS film 14, a Ti film 15, a TiN film 16, an AlCu film 17 and a blanket W film 18 are laminated in this order on an Si substrate 12. The wafer 1 is held on a wafer carrier 2, the lower surface of the wafer 1 is brought into contact with a polishing pad 5 on a surface plate 6, and the wafer 1 is polished with an abrasive particle solution fed through an abrasive particle solution feed pipe 3 and ozones fed through an ozone generator 9. That is, a metal film oxidized with an abrasive which does not contain metallic ions can be removed. By this abrasion, the part, which is buried in the whole surface of the wafer 1 having a through-hole, of the W film 18 can be removed and a W plug 20 is formed.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[The technical field to which invention belongs] Especially this invention relates to the polish method of a metal membrane using the chemical mechanical grinding (Chemical Mechanical Polishing:CMP) method, and its polish equipment about the manufacture method of a semiconductor device, and a manufacturing installation.

[0002]

[Description of the Prior Art] As shown in drawing 9 (a), by the manufacture method of the conventional semiconductor device, the semiconductor substrate (henceforth a wafer) which laid the contact hole 41 in the bottom insulator layer 22 of wiring of the Si substrate 38 (BPSG film) underground by the 1000nm blanket W film 40 was manufactured, next this wafer was processed by the chemical / mechanical polishing (CMP) method which acts alternatively about the W film 40.

[0003] This CMP was performed on the polishing pad carried on the rotation platen, and the slurry containing acids, such as a polish nature particle of aluminum2O3 grade and Fe (NO3)3, H2O2, KOH, or NH4OH, and a base was used for it. This CMP method is indicated by the specification of USP No. 4,992,135. By this method, the front face became a concave and the W film 40 laid under the contact hole 41 in the BPSG film 39 as shown in drawing 9 (b) formed W film concave plug 42.

[0004] Here, CMP which acts alternatively to the BPSG film 39 as a method of improving W film concave plug 42 which has become depressed to the surrounding BPSG film 39 was performed. The slurry used by this CMP uses a colloid nature silica slurry, and contains H2O2 which act alternatively to the BPSG film 39, KOH, etc. This CMP was continuously performed until W film convex plug 43 was obtained so that drawing 9 (c) might see.

[0005]

[Problem(s) to be Solved by the Invention] However, in the conventional example shown in drawing 9 , there was a problem that the possibility of metal contamination was large.

[0006] The reason is because W-CMP of the 1st step is performed using the slurry containing oxidizers, such as Fe (NO3)3 and KOH. Here, the oxidizer of Fe(NO3)3 grade is used for oxidizing W film powerfully and enabling it for a polish particle to remove easily. That is, it is for raising the throughput which enlarges polish speed and starts a polish process.

[0007] Furthermore, in the conventional example, there was a problem that the CMP process by the oxide-film slurry had to be added as the 2nd step.

[0008] The reason is for canceling the concave on the front face of a plug by W-CMP of the 1st step, and canceling the crack on the front face of an oxide film. Furthermore, it is also for removing the metal contamination which

adhered to the wafer front face by giving the 2nd step oxide film CMP on the occasion of the 1st step to a certain level.

[0009] The purpose of this invention is to offer the polish method of the metal membrane to which metal contamination is reduced, and polish equipment.

[0010]

[Means for Solving the Problem] In order to attain the aforementioned purpose, the polish method of the metal membrane concerning this invention removes the metal membrane which oxidized the metal using the oxidizer which does not contain a metal ion, and oxidized using the abrasive material containing a polish particle in the polish method of the metal membrane which grinds the wafer with which the metal membrane was formed.

[0011] Moreover, the oxidizer used at the process which oxidizes the aforementioned metal membrane is a gas.

[0012] Moreover, the aforementioned gas is ozone.

[0013] Moreover, the polish equipment concerning this invention has a means to oxidize a metal using the oxidizer which does not contain a metal ion, and a means to remove the metal membrane which oxidized using the abrasive material containing a polish particle, in the polish equipment which grinds the wafer with which the metal membrane was formed.

[0014] Moreover, a gas is used as an oxidizer which oxidizes the aforementioned metal membrane.

[0015] Moreover, ozone is used as the aforementioned gas.

[0016] Moreover, in case the aforementioned ozone is supplied to the front face of a semiconductor substrate, it has the pressure regulator to which an ozone speed of supply is made to increase in the middle of the line supplied from the ozonator attached to polish equipment to polish pad opening on the surface plate of polish equipment.

[0017] Moreover, in case the aforementioned ozone is supplied to the front face of a semiconductor substrate, a polish particle solution supply pipe supplies the ozone from an ozonator to a polish pad front face independently within the unit equipped with the exhaust port.

[0018] Moreover, in case the aforementioned ozone is supplied to the front face of a semiconductor substrate, ozone is supplied from an ozonator in the middle of a polish particle solution supply pipe, it mixes with a polish particle solution and even the polish pad on the surface plate of polish equipment supplies.

[0019] In this invention, the ozone which is a gas is used for the oxidizer in the process which grinds a metal membrane. According to this method, polish speed can be enlarged, without making a metal impurity mix. Moreover, since ozone does not contain the metal, it does not have the need for the removal of a metal impurity which was being conventionally performed at the 2nd step. Furthermore, there is also no seam (void) which is easy to generate in the center section of the W plug generated in the polish using the oxidizer of H2O2. Consequently, W plug could be efficiently formed by CMP of only the 1st step, and it led to the improvement in the yield of a semiconductor device.

[0020]

[Embodiments of the Invention] Next, the operation gestalt of this invention is explained in detail with reference to a drawing.

[0021] (Operation gestalt 1) Drawing 1 is the block diagram showing the operation gestalt 1 of this invention.

[0022] The polish equipment concerning the operation gestalt 1 of this invention shown in drawing 1 The wafer carrier 2 which turns the semiconductor substrate (henceforth a wafer) 1 caudad, and holds it, It has the polish particle solution supply pipe 3 which supplies a polish particle solution on the polish pad 5, the ozone supply pipe 7 which supplies the ozone generated from an ozonator 9 on the polish pad 5 through a pressure regulator 8, and the polish pad 5 which supplies the ozone from the ozone supply pipe 7 to the upper part from opening.

[0023] Drawing 2 shows the enlarged view of a surface plate 6 and the polish pad 5, and drawing 3 shows the front face of a polish pad. Here, the polish particle used has an alumina (aluminum 2O3) particle or a desirable silica (SiO2) particle. Moreover, the polish pad 5 has the hard polyurethane of an independent foam, the nonwoven fabric of a continuation foam, and the desirable polish pad of those laminated structures.

[0024] Next, operation of the operation gestalt 1 of this invention is explained with reference to the polish equipment of drawing 1 . As shown in drawing 5 (a), for example, on the Si substrate 12, the BPSG film 13, the PE-TEOS film 14, the Ti film 15, the TiN film 16, the AlCu film 17, and the blanket W film 18 carry out the laminating of the wafer 1 one by one, and it is formed. As shown in drawing 5 (a), the wafer 1 which forms the metal membrane (blanket W film 18) in a front face is held on the wafer carrier 2, the inferior surface of tongue of a wafer 1 is contacted to the polish pad 5 of a surface plate 6, and it grinds by the ozone supplied from the polish particle solution supplied from the polish particle solution supply pipe 3, and the ozonator 9. That is, according to the operation gestalt 1 of this invention, the metal membrane which oxidized the metal using the oxidizer which does not contain a metal ion, and oxidized using the abrasive material containing a polish particle will be removed. Of this polish, as shown in drawing 5 (b), the W film 18 laid underground all over the wafer 1 which has a through hole can be removed, and the W plug 20 is formed. It is necessary to adjust ****** of the ozone supplied from the ozone feed hopper 4 of drawing 1 to the pressure by which the polish particle solution supplied from the polish particle solution supply pipe 3 does not flow into the ozone feed hopper 4 at this time.

[0025] (Operation gestalt 2) Drawing 6 is the block diagram showing the operation gestalt 2 of this invention. The polish equipment concerning the operation gestalt 2 of this invention shown in drawing 6 The polish particle solution supply pipe 22 which supplies a polish particle solution on the wafer 25 held at the wafer carrier 26, The ozone supply pipe 21 which supplies the ozone generated from an ozonator on a wafer 25, It has the small polish pad 24 for polish held at the polish pad maintenance carrier 23, the polish unit 28 which seals the polish section for using ozone effectively, and the exhaust port 27 which exhausts the ozone saturating to the lower part of the polish unit 28 by the constant rate. Here, the wafer 25 is characterized by the front face ground being upward.

[0026] Next, operation of the operation gestalt 2 of this invention is explained with reference to drawing 6 . The front face which has the wafer 25 (refer to drawing 5) which forms the metal membrane in a front face ground is turned upward, and it installs in the wafer carrier 26, and grinds by the ozone supplied from the polish particle solution supplied from the polish particle solution supply pipe 22, and the ozone supply pipe 21. That is, according to the operation gestalt 2 of this invention, the metal membrane which oxidized the metal using the oxidizer which does not contain a metal ion, and oxidized using the abrasive material containing a polish particle will be removed. The W plug 20 as shown in drawing 5 (b) by this polish is formed. At this time, when the supplied ozone will be in a saturation state, it is necessary to exhaust ozone from the exhaust port 27 of the polish unit 28.

[0027] (Operation gestalt 3) Drawing 7 is the block diagram showing the operation gestalt 3 of this invention.
[0028] The polish equipment concerning the operation gestalt 3 of this invention shown in drawing 7 The wafer 29 held at the wafer carrier 30, and the polish particle solution supply pipe 36 which supplies a polish particle solution on the polish pad 31, The ozonator 33 which supplies ozone in the middle of the polish particle solution supply pipe 36, It has the ozone polish particle mixed-solution supply pipe 37 for supplying the ozone and the polish particle solution which were mixed to the polish pad 31, and the rotary pump 34 for supplying an ozone polish particle mixed solution on the polish pad 31 efficiently.
[0029] Next, operation of the operation gestalt 3 of this invention is explained with reference to drawing 7 . The wafer 29 with which the metal membrane was formed by the wafer carrier 30 on the front face is held, and the polish particle solution supplied from the polish particle solution supply pipe 36 and the ozone supplied from the ozonator 33 are mixed. The mixed solution supplied from this ozone polish particle mixed-solution supply pipe 37 is ground by being dropped at the polish pad 31. That is, according to the operation gestalt 3 of this invention, the metal membrane which oxidized the metal using the oxidizer which does not contain a metal ion, and oxidized using the abrasive material containing a polish particle will be removed. The W plug 20 as shown in drawing 5 (b) by this polish is formed. At this time, after the polish particle solution 35 which is the ozone and the liquid which are a gas is mixed, it is necessary to operate the rotary pump 34 which can be efficiently supplied on the polish pad 31.
[0030] (Example 1) Below, an example is used and the operation gestalt of this invention is explained.
[0031] It attaches in the wafer carrier 2 of the polish equipment which shows the wafer 1 which has the semiconductor device with which the blanket W film 18 as shown in drawing 5 (a) was formed to drawing 1 , and the W film 18 is ground with the polish particle solution supplied from the polish particle solution supply pipe 3.
[0032] In that case, opening of the ozone feed hopper 4 as shown in drawing 2 is carried out to the polish pad 5, and ozone is supplied to the polish pad 5 through the ozone supply pipe 7 from the ozonator 9 shown in drawing 1 . Conventionally, instead of the oxidizer currently supplied on the polish pad as a solution, this ozone is adjusting ****** with the pressure regulator 8 so that a polish particle solution may not advance into the ozone feed hopper 4.
[0033] Moreover, drawing 3 shows the front face of the polish pad 5, and in case a wafer 1 is polish, the ozone feed hopper 4 is formed in the polish field 10 in contact with the polish pad 11 (5). A diameter is 5mm and the ozone feed hopper 4 is located in a line on the diagonal line.
[0034] Next, operation of the example 1 of this invention is explained in detail with reference to a drawing.
[0035] Drawing 5 shows the polish process by the polish method concerning this invention. The cross-section structure of the wafer 1 before polish is shown in drawing 5 (a), after using an atmospheric pressure CVD system and depositing the BPSG film 13 on the Si substrate 12 at the thickness of 0.5 micrometers, heat treatment with the lamp for 30 seconds is performed in 700-degree C nitrogen-gas-atmosphere mind, and the bottom insulator layer of wiring is formed. Next, on the BPSG film 13, the aluminum film 17 and the titanium-nitride (TiN) film 16 which contain the titanium (Ti) film 15, the titanium-nitride (TiN) film 16, and copper by the sputtering method are deposited, respectively, thickness is set to 1 micrometer, carries out patterning, and wiring is formed.
[0036] Next, 2 micrometers of plasma TEOS oxide films 14 (henceforth PE-TEOS) which use a tetrapod ethoxy orthochromatic silicate (TEOS) as a raw material using a plasma-chemistry vapor growth (henceforth CVD) are

formed. Next, flattening of this PE-TEOS film 14 is carried out by the oxide-film CMP method (not shown).

[0037] Furthermore, after carrying out opening of the through hole on wiring by the reactive-ion-etching method and depositing 0.1 micrometers of titanium-nitride (TiN) films 16 by the sputtering method, the blanket W film 18 is formed by CVD. The wafer 1 shown in drawing 5 (a) is ground using the polish equipment shown in drawing 1 . The ozone whose oxidizer the polish particle at the time of polish is the alumina particle solution of 50nm of pH 4.0 particle diameters, and is a gas is used. An alumina particle is directly dropped on the polish pad 5 from the polish particle solution supply pipe 9. Ozone is made with an ozonator 9 and sent to the ozone supply pipe 7 in a surface plate 6 through a pressure regulator 8. And it is sent to the front face of the polish pad 5 which the wafer 1 and polish particle solution to which a load is applied, and which are rotating are dropped, and is rotating. For the load by which the polish conditions at this time are added to rotational frequency 5rpm of a surface plate 6, rotational frequency 35rpm holding the wafer 1 of the wafer carrier 2, and a wafer 1, 5.0psi(s) and a polish particle solution supply flow rate are [120 g/m3 and the ozone supply pressure of 100 cc/min and ozone supply concentration] 1.5 atmospheric pressure. By making it this atmospheric pressure, the polish particle solution currently simultaneously supplied to the front face of the polish pad 5 has prevented flowing into the ozone feed hopper 4.

[0038] If the W film 18 of wafer 1 front face is completely removed using the above polish conditions, the W plug 20 as shown in drawing 5 (b) will be obtained. The polish speed at this time is increasing by about 1.9 times at the time of using H2O2 as an oxidizer which does not contain a metal, as shown in drawing 8 . Thus, the CMP process which is made to increase polish speed and does not contain a metal impurity is established. Moreover, when ozone is used for the crack on the front face of an oxide film canceled at the 2nd conventional step as an oxidizer, there is no generating of a crack on the surface of an oxide film, a smooth front face is obtained, and it is not necessary to perform the 2nd conventional step. Furthermore, since shortening of the processing time which starts per wafer for high polish speed is possible, the throughput in semiconductor manufacture can be raised.

[0039] In addition, although the alumina particle of 50nm of particle diameters was used, it cannot be overemphasized here that the same effect is acquired by other particle diameters and other particle specieses.

[0040] (Example 2) Next, the composition of the example 2 of this invention is explained in detail with reference to a drawing.

[0041] It attaches so that the front face ground by the wafer carrier 25 of the polish equipment which shows the wafer 25 with which the blanket W film 18 as shown in drawing 5 (a) was formed to drawing 6 may become upward, and the W film 18 is ground using the polish particle solution supplied from the polish particle solution supply pipe 22, and the ozone supplied from the ozone supply pipe 21. Opening of the sealing-the polish section for using ozone effectively polish unit 28 and the exhaust port 27 which exhausts the ozone saturating to the lower part of the polish unit 28 by the constant rate is carried out to the polish equipment of drawing 6 used in that case.

[0042] Next, operation of the example 2 of this invention is explained in detail with reference to a drawing.

[0043] Drawing 5 shows the polish process by the polish method concerning this invention, and produces a wafer with the structure of drawing 5 (a) as well as an example 1. The wafer which has the structure of this drawing 5 (a) is ground using the polish equipment shown in drawing 6 . The ozone whose oxidizer the polish particle at the time of polish is the alumina particle solution of 50nm of pH 4.0 particle diameters, and is a gas is used. An alumina

particle is directly dropped at a wafer 25 from the polish particle solution supply pipe 22. This wafer 25 is installed in the wafer carrier 26 so that the front face ground may become upward. Furthermore, the ozone made with the ozonator is sent to a wafer 25 through the ozone supply pipe 21. And for the load by which the rotational frequency of the wafer carrier 26 which, as for the rotational frequency of the polish pad maintenance carrier 23 with which, as for the polish conditions at this time, the polish pad 24 is held, holds 50rpm and the wafer 25 is applied to 35rpm and the polish putt 24, 5.0psi(s) and a polish particle solution supply flow rate are [120 g/m3 and the ozone supply pressure of 100 cc/min and ozone supply concentration] 1.0 atmospheric pressure. By this method, since ozone is always supplied to the polish section, you have to exhaust the ozone in the saturated polish unit 28 through an exhaust port 27. The exhaust pressure at this time has desirable 20 - 50mmH2O. If the W film 18 of wafer 25 front face is completely removed using the above polish conditions, the W plug 20 as shown in drawing 5 (b) will be obtained. The polish speed at this time is a polish speed shown in drawing 8 like an example 1. Thus, polish speed is made to increase and the CMP process which does not contain a metal impurity is established. Moreover, even if it uses the polish equipment of drawing 6 , when ozone is used for the crack on the front face of an oxide film canceled at the 2nd conventional step as an oxidizer, there is no generating of a crack in an oxide-film front face, a smooth front face is obtained, and it is not necessary to perform the 2nd conventional step. Furthermore, since shortening of the processing time concerning per wafer is possible because of high polish speed, the throughput in semiconductor manufacture can be raised.

[0044] In addition, like an example 1, although the alumina particle of 50nm of particle diameters was used, it cannot be overemphasized here that the same effect is acquired by other particle diameters and other particle specieses.

[0045] (Example 3) Next, the composition of the example 3 of this invention is explained in detail with reference to a drawing.

[0046] The W film 18 grinds using the ozone polish particle mixed-solution supply pipe 37 for supplying the ozonator 33 which can supply ozone in the middle of, and the ozone and the polish particle solution which were mixed further at the polish pad 31 on the wafer 29 held at the wafer carrier 30 of the polish equipment which shows the wafer 25 with which the blanket W film 18 as shown in drawing 5 (a) was formed to drawing 7 , and the polish pad 31. [the polish particle solution supply pipe 36] It is necessary to supply efficiently the mixed liquor of the polish particle solution which is the ozone and the liquid which are a gas on the polish pad 31 using a rotary pump 34 at this time.

[0047] Next, operation of the example 3 of this invention is explained in detail with reference to a drawing.

[0048] Drawing 5 shows the polish process by the polish method concerning this invention, and produces a wafer with the structure of drawing 5 (a) as well as an example 1. The wafer which has the structure of this drawing 5 (a) is ground using the polish equipment shown in drawing 7 . The ozone whose oxidizer the polish particle at the time of polish is the alumina particle solution of 50nm of pH 4.0 particle diameters, and is a gas is used. The wafer 29 which forms the metal membrane in a front face is held on the wafer carrier 30, and the polish particle solution supplied from the polish particle solution supply pipe 36 and the ozone supplied from the ozonator 33 are mixed. It grinds by dropping the mixed solution supplied from the ozone polish particle mixed-solution supply pipe 37 at the

polish pad 31. At this time, a rotary pump 34 is operated so that it may be supplied on the polish pad 31 efficiently [after mixing the polish particle solution 35 which is the ozone and the liquid which are a gas]. And the pressure by which 100 cc/min and ozone supply concentration supply [the load by which the rotational frequency of 35rpm and a surface plate 32 is applied to 50rpm and the wafer 29 for the rotational frequency of the wafer carrier 30 with which, as for the polish conditions at this time, the wafer 29 is held] ozone to 120g/m3, and a polish particle solution in 5.0psi(s) and a polish particle solution supply flow rate is 1.5 atmospheric pressure. The W plug 20 as shown in drawing 5 (b) by this polish is formed.

[0049] If the W film 18 of wafer 25 front face is completely removed using the above polish conditions, the W plug 20 as shown in drawing 5 (b) will be obtained. The polish speed at this time is a polish speed shown in drawing 8 like an example 1. Thus, polish speed is made to increase and the CMP process which does not contain a metal impurity is established. Moreover, even if it uses the polish equipment of drawing 7 , when ozone is used for the crack on the front face of an oxide film canceled at the 2nd conventional step as an oxidizer, there is no generating of a crack in an oxide-film front face, a smooth front face is obtained, and it is not necessary to perform the 2nd conventional step. Furthermore, since shortening of the processing time concerning per wafer is possible because of high polish speed, the throughput in semiconductor manufacture can be raised.

[0050] In addition, like examples 1 and 2, although the alumina particle of 50nm of particle diameters was used, it cannot be overemphasized here that the same effect is acquired by other particle diameters and other particle specieses.

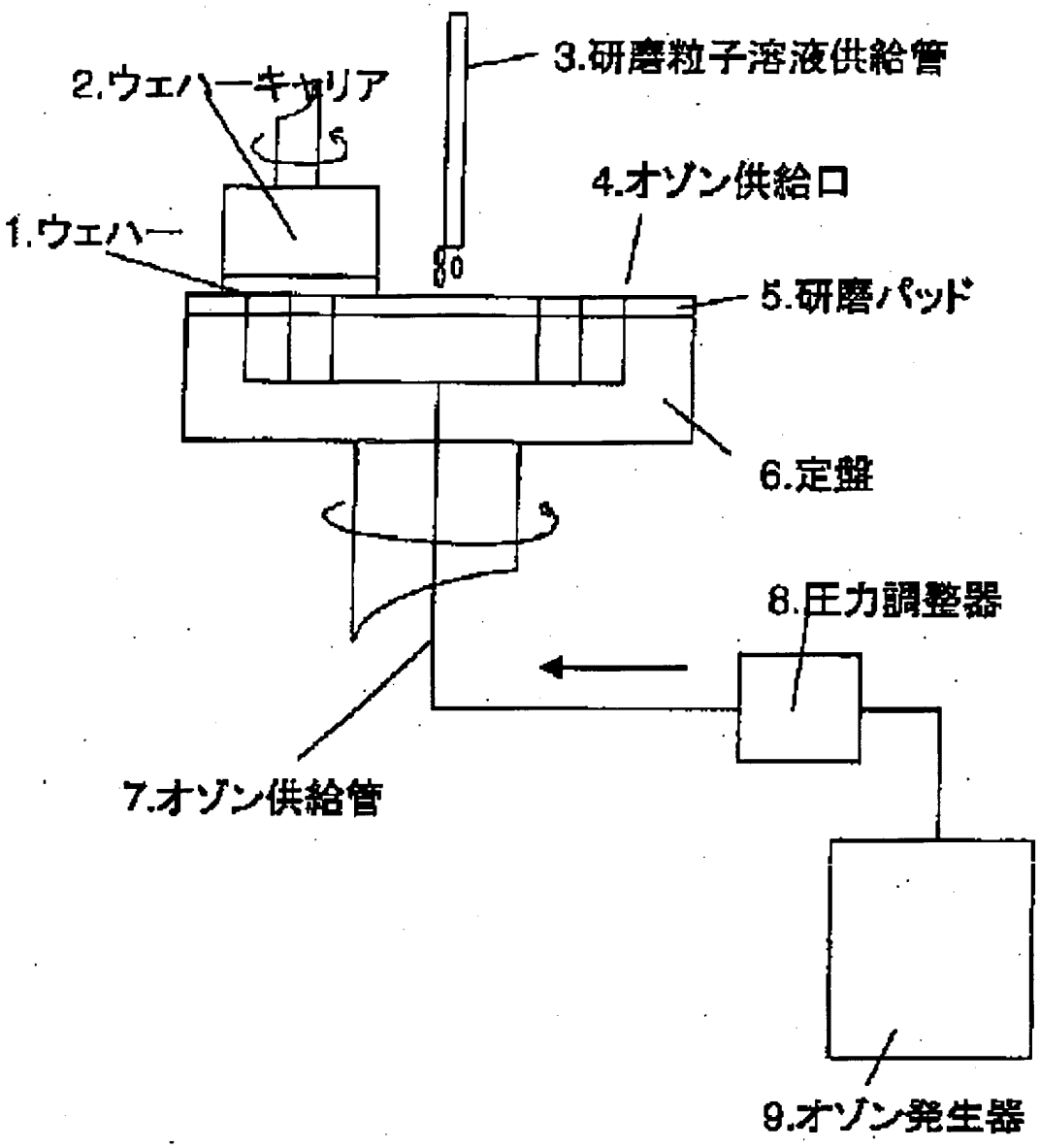
[0051]

[Effect of the Invention] Maintenance of the high polish speed which had been conventionally attained by the oxidizer of Fe(NO3)3 grade is also possible by being able to perform W-CMP, without using the slurry containing oxidizers, such as Fe (NO3)3 and KOH, according to this invention, being able to prevent metal contamination, as explained above, and moreover using ozone.

[0052] Furthermore, since ozone is used, pervasion by the oxidizer of W film does not occur like the conventional oxidizer, and a concave does not occur on a plug front face, but the 2nd step CMP by the oxide-film slurry becomes unnecessary like before. Since the metal is not contained in an oxidizer, it becomes unnecessary moreover, to remove the metal contamination which had adhered to the wafer front face on the occasion of the 1st conventional step.

[Translation done.]

Drawing 1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7.オゾン供給管
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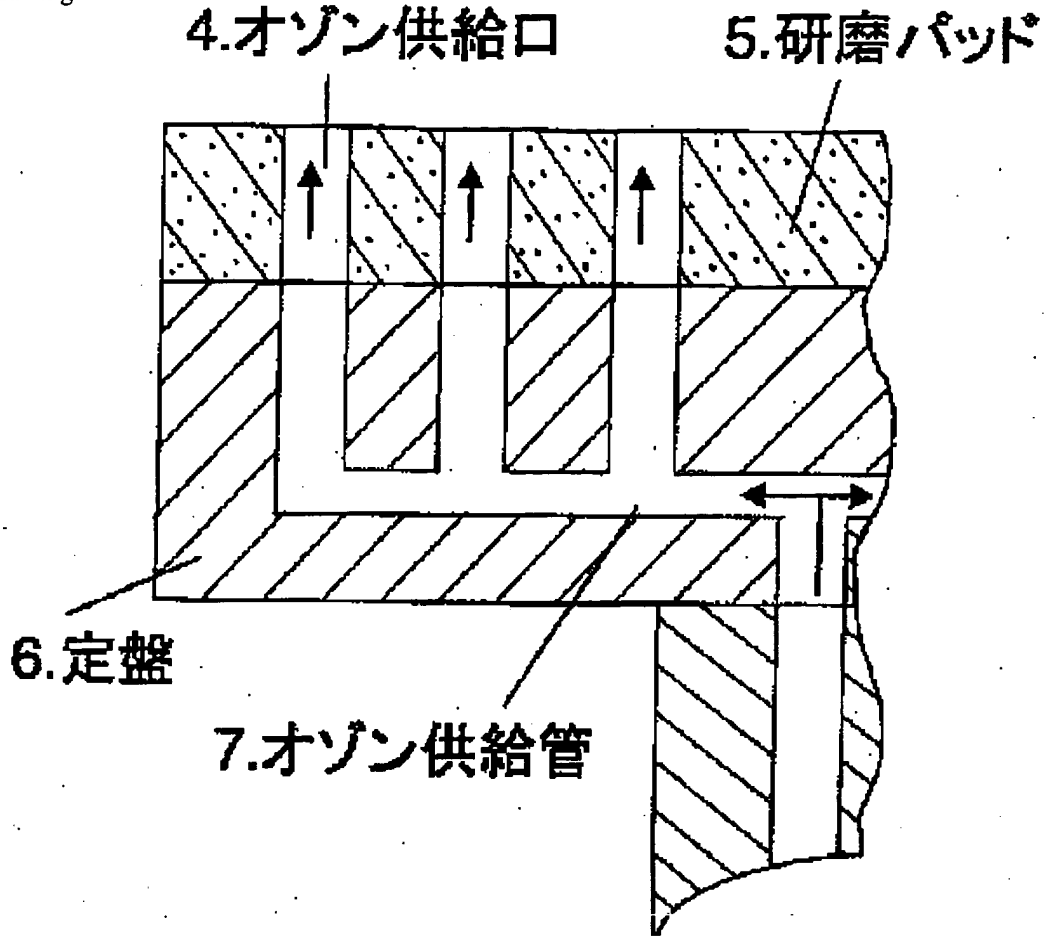

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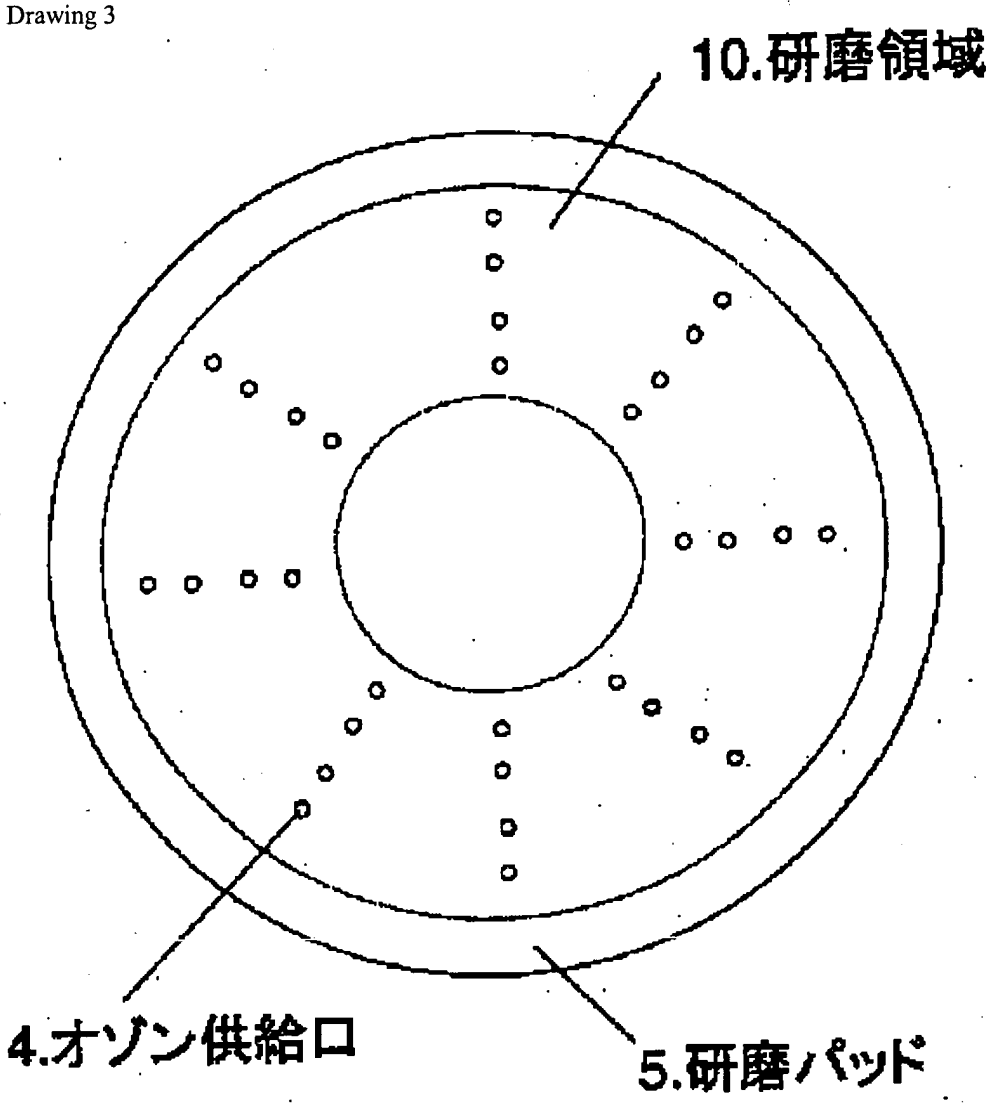

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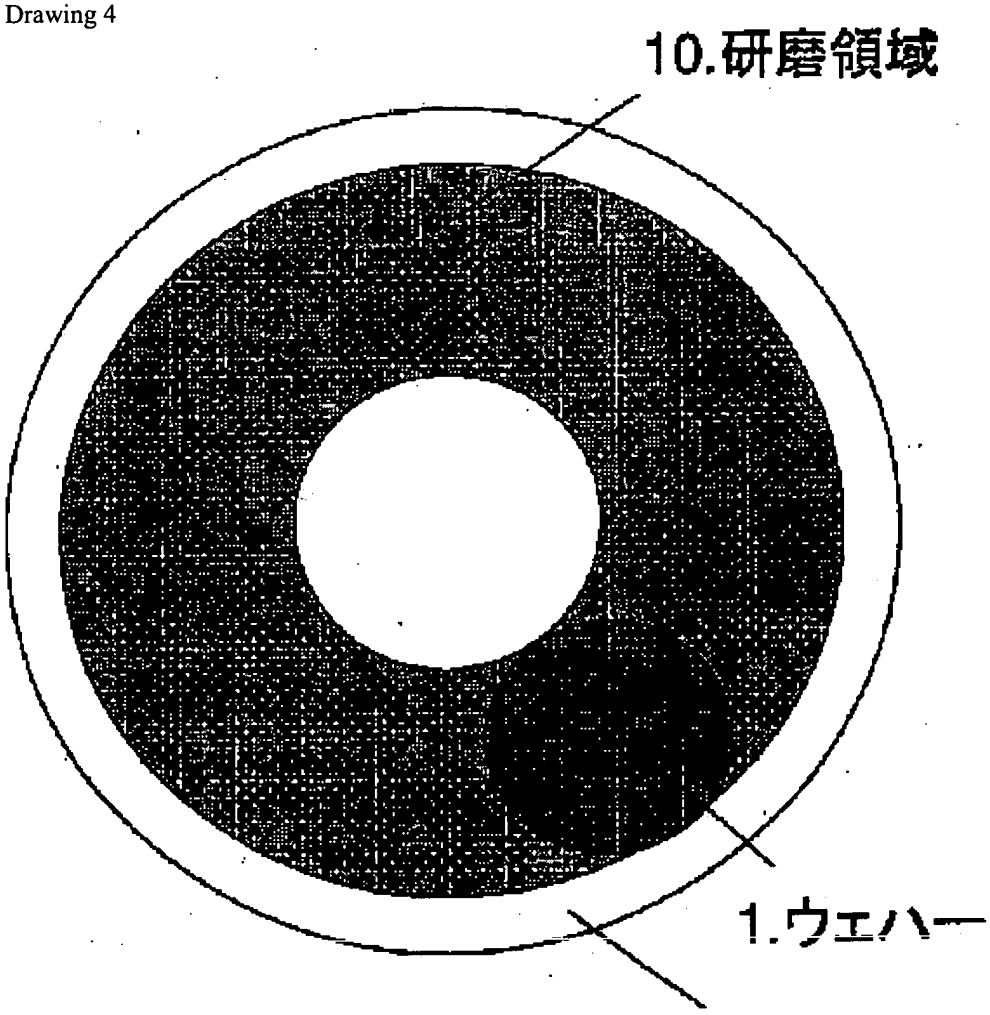

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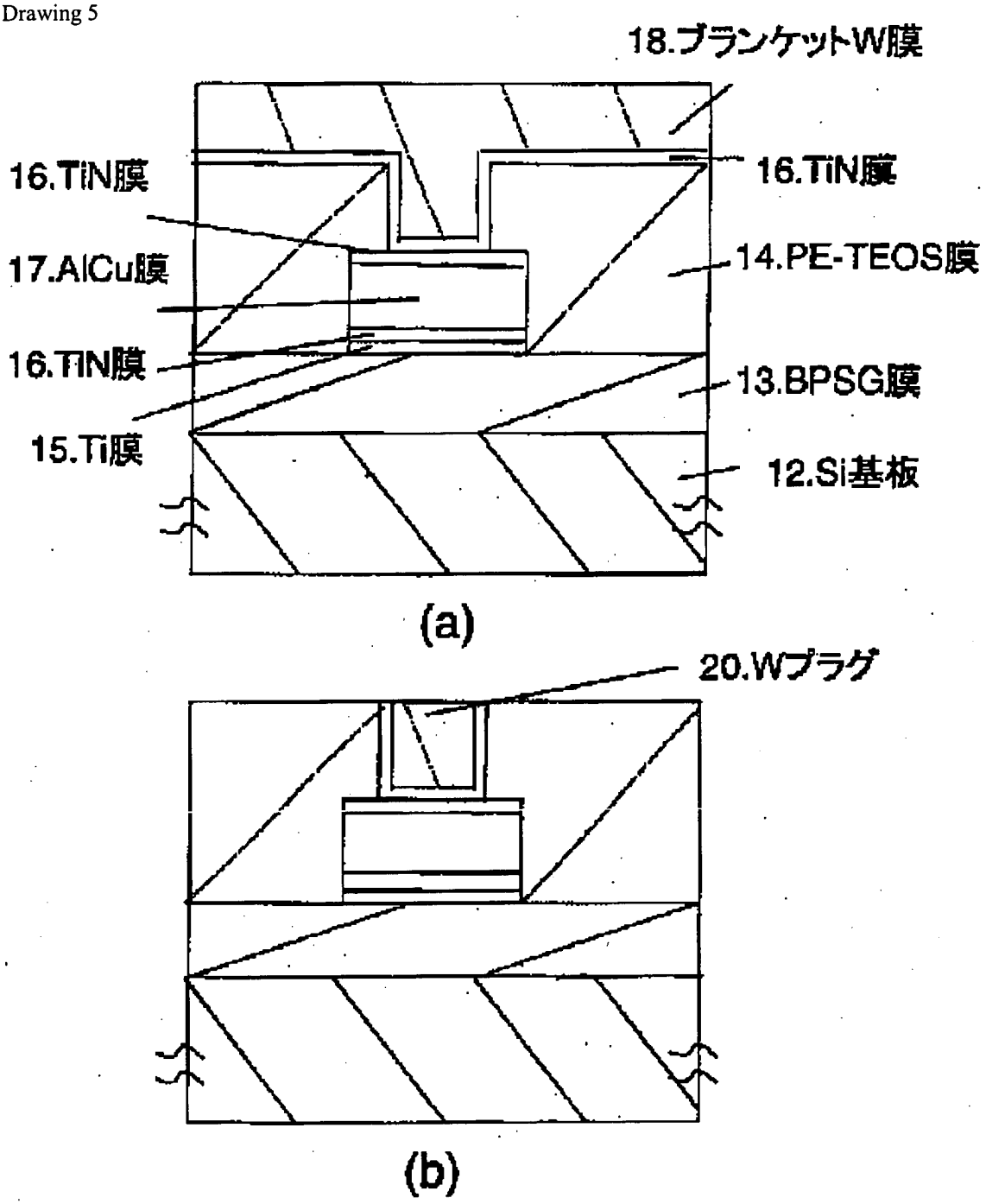
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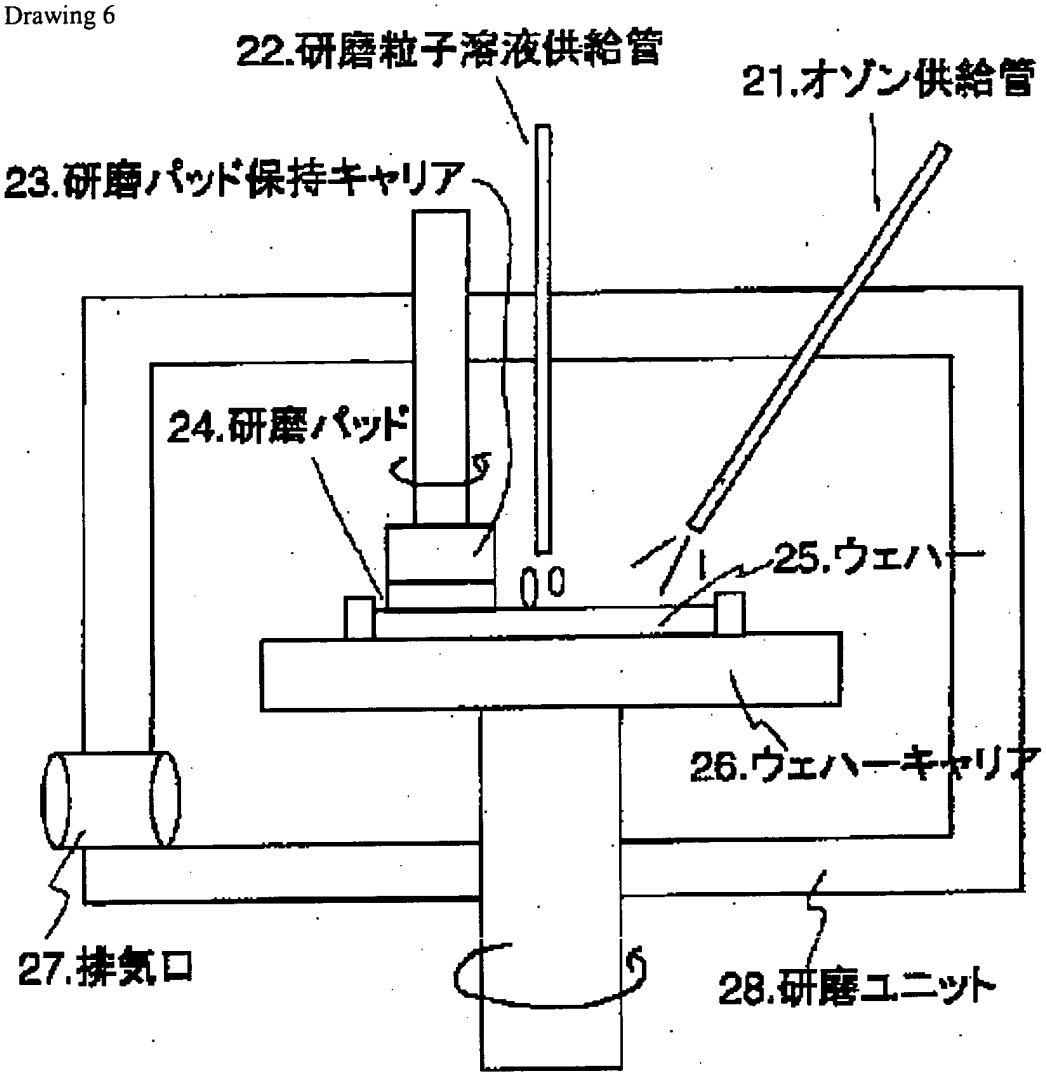
(b)

Drawing 6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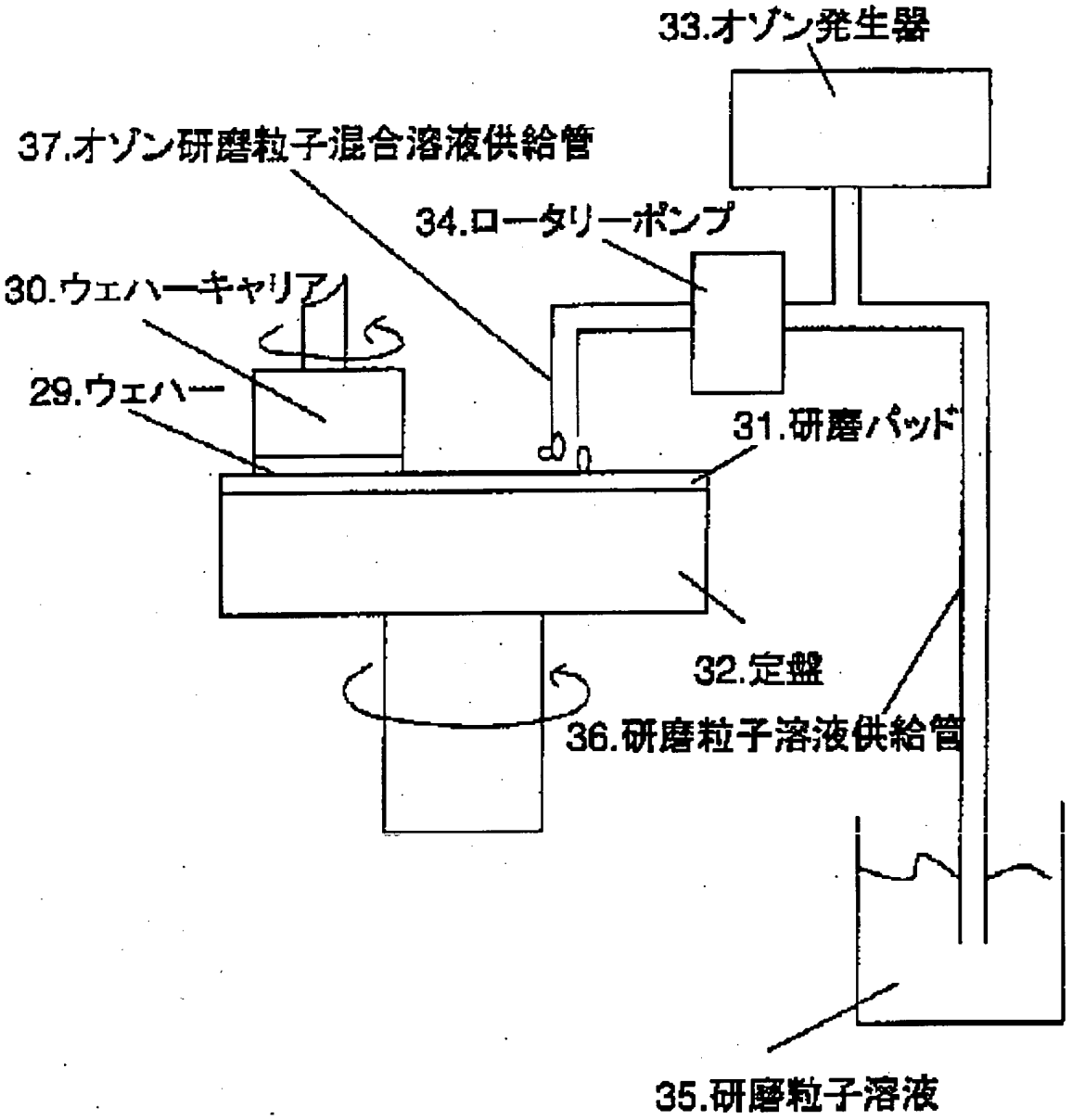
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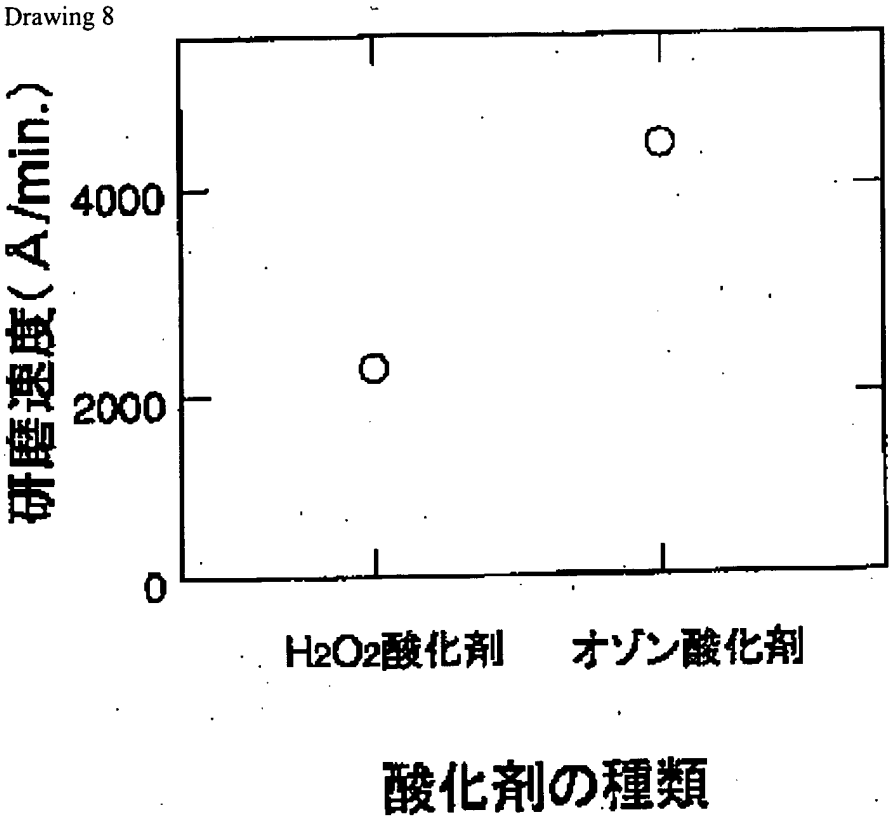
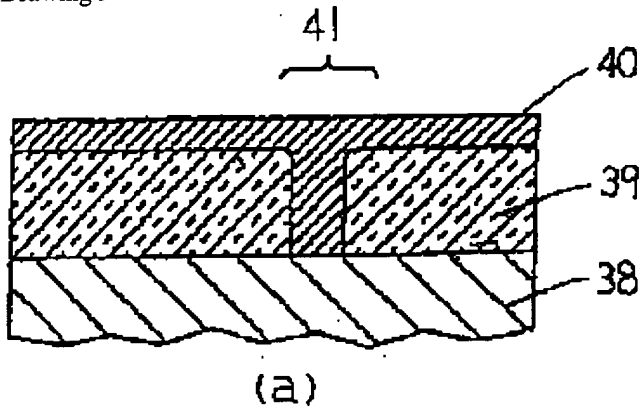
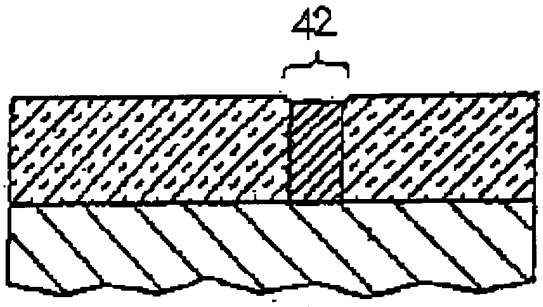


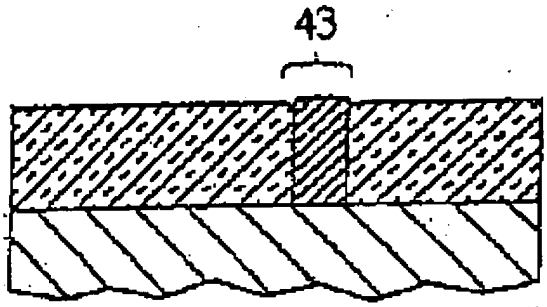
Drawing 9



(a)



(b)



(c)